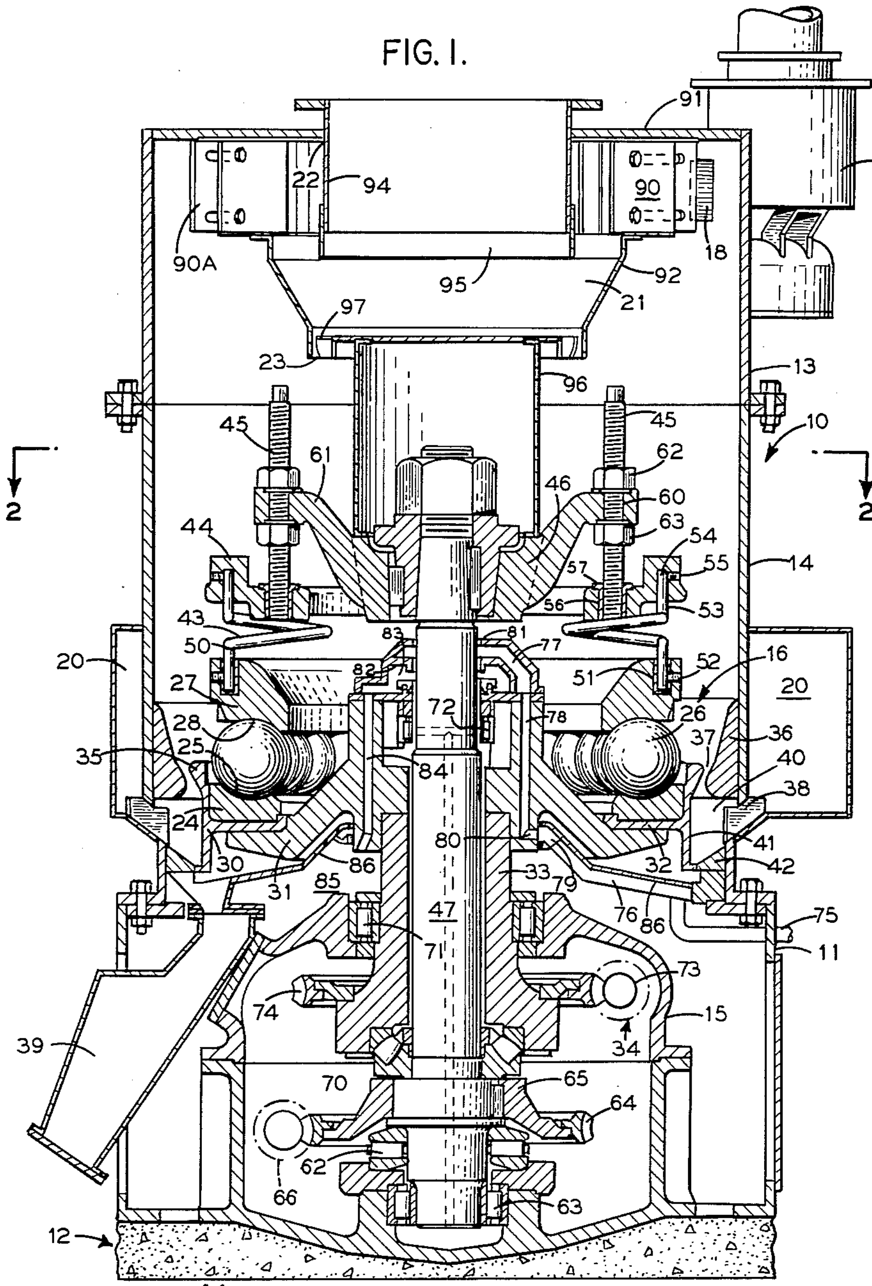
Aug. 10, 1965 E. M. POOLE 3,199,794

PULVERIZER

Filed May 23, 1962

FIG. I.



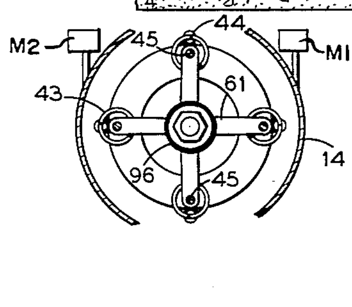


FIG. 2

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3,199,794
PULVERIZER

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This invention relates in general to improvements in the construction and operation of pulverizers, and more particularly to pulverizers in which a circular series of rolling grinding elements are positioned between relatively moving upper and lower grinding rings. The rings of the pulverizer are urged together to exert a pressure on the contacting surfaces of the rings and balls so that raw materials introduced generally into the grinding zone formed by the rings and balls will be pulverized in passing outwardly therethrough for discharge from the outer periphery of the zone. Certain features of the pulverizer disclosed in this application are disclosed and claimed in copending applications of Neil W. Eft and Richard A. Miller filed May 23, 1962, Serial No. 197,062; and of James L. Harvey and Alden Q. Beaty filed May 29, 1962, Serial No. 198,682, now Patent 3,093,327 issued July 11, 1963.

In the present invention a pulverizer of the ring and ball type is provided wherein the upper and lower rings are rotated in opposite directions to increase the effective grinding area utilized in pulverization. The increased grinding area increases the capacity of the pulverizer without a corresponding increase in its size, and without increasing the centrifugal forces imposed on the rolling grinding elements operating between the rotating upper and lower rings. The rates of rotation of the upper and lower rings are different so that the circular row of rolling grinding elements will rotate at a slow speed about the central axis of the ring drive shafts. The centrifugal forces imposed on such elements will be low while the effective grinding surface is high relative to the floor area occupied by the pulverizer.

The invention is particularly useful in a pulverizer arranged for air-swept service, as in preparing solid fuels, such as bituminous coal, for suspension burning. In such an arrangement, carrier air is passed upwardly in an annular stream around the periphery of the pulverizing elements or zone to entrain the discharged wholly and partially pulverized solids, which are thereafter classified in the upper portion of the pulverizer. The classification stage separates the desired finished product, for air-borne removal from the pulverizer, from the oversized materials which are returned to the grinding elements for further pulverization.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is an elevation, in section, of a pulverizer constructed and arranged in accordance with the present invention; and

FIG. 2 is a section taken along line 2—2 of FIG. 1.

In general, the pulverizer of the invention includes a housing enclosing a pulverizing zone in the lower portion and a classifying zone in the upper portion thereof. The pulverizing zone consists of upper and lower grinding rings, rotated in opposite directions, with a circular row of rolling grinding elements positioned between the grinding rings. The upper and lower grinding rings may be driven in any desired manner by a common motor or by separate motors, or other prime movers.

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In the illustrated embodiment of the invention, a preferred pulverizer construction includes a cylindrical upper housing section 10 and a lower housing section 11 supported on a foundation 12. The sections 10 and 11 are fastened together for ease of assembly, and the section 10 may be made in two cylindrical portions 13 and 14 for ease of access to the grinding and classification zones hereinafter described. The lower housing section 11 encloses a gear housing 15 which is separately supported by the foundation 12. As hereinafter described the gear housing 15 contains two worm-gear speed reducers each connected to its respective drive shaft, one of which drives the lower grinding ring while the other drives the upper grinding ring, both rings being positioned within the pulverizing or grinding zone 16. Each worm-gear reducer is directly connected with a separate, externally positioned drive motor (not shown).

Raw coal supplied to a regulable feeder 17 discharges the coal into the grinding zone 16 through a chute 18 extending through the housing 10 from the feeder. Air, at superatmospheric pressure, enters the lower section 14 of the pulverizer housing 10 through an encircling duct 20, to pass upwardly adjacent the outer side or periphery of the grinding zone 16, entraining comminuted coal, and thence through a classifier or separator 21, with the air-borne finished product leaving the pulverizer housing section 13 through a centrally located upper outlet 22. The oversized material is passed downwardly from the classifier 21 into an annular discharge port 23 for return to the pulverizing zone 16.

The grinding zone of the pulverizer includes a lower horizontally disposed grinding ring 24 having a circular groove or race 25 formed in its upper face to support a circular row of grinding balls 26. The balls in turn support an upper grinding ring 27 which is provided with a circular groove or race 28 in its lower face engaging the circular row of balls. In accordance with this invention both the upper and lower grinding rings 27 and 24, respectively, are rotated, but in opposite directions and at different rates of rotation. The rate of rotation of the row of balls about the axis of ring rotation will generally be equal to one-half the difference between the rates of ring rotation. This low ball row rotation rate results in a low value of centrifugal force imposed on the balls while maintaining a high rate of application of grinding force or work on the material being pulverized in any unit of time, leading to extremely high rates of pulverization per unit of floor space occupied by the pulverizer.

The lower grinding ring 24 is provided with a flat lower face supported on and pinned to a T shaped annular ledge member 30 and to the annular upper surface of a generally conical driving rotor 31, the shank 32 of the member 30 being interposed between the ring 24 and the rotor 31. The rotor 31 is affixed to the upper end portion of a stub shaft 33 which is rotated by a worm-gear drive assembly 34 positioned in the upper portion of the gear housing 15.

As shown in FIG. 1, the generally vertical arms of the member 30 extend above and below the shank 32. The upper arm 35 of the member 30 forms an upstanding ledge to restrict the flow of pulverized material from the grinding zone 16, while the outer surface of the arm 35 is shaped to cooperate with a stationary ring member 36 in defining a throat 37 for directing the upward flow of entraining air within the grinding zone. As shown, the cooperating surfaces defining the throat 37 direct the entraining air upwardly and slightly outwardly toward the housing section 14 of the pulverizer. Thus, the air passing through the duct 20 enters the pulverizer housing section 14 through a vaned annular opening 38 discharging in an inward direction into a chamber 40 and thence upwardly through the throat. The chamber 40 is inwardly defined by the upper and lower arms 35 and 41, respectively of the rotating member 30, a lower fixed ring 42, and at the top by the lower portion of member 36, and in part by the throat opening 37. The ring 36 is provided with a spring loaded displaceable section (not shown) which will be forced outwardly toward the housing by foreign materials such as tramp iron, or the like. Such foreign materials will fall by gravity into chamber 40 and discharge downwardly into box 39, from which the materials may be periodically removed.

The upper ring 27 is rotated and urged downwardly against the row of balls by a plurality of circumferentially equally spaced, single turn coil springs 43 which are in turn attached to an annular member 44, upright bolts 45, and a drive yoke 46 which is attached to the upper end portion of a shaft 47. The coil of each of the springs 43 is generally horizontally oriented and provided with oppositely extending upright end portions. The lower end extension 50 of each spring projects downwardly into a pocket or recess 51 formed in the upper outer portion of the ring 27 and is locked in place by a set screw 52. The opposite, or upper end extension 53 of each spring is fitted into a recess 54 formed in the lower portion of the member 44 and is locked in place by a set screw 55. Each of the recesses 51 and 54 are positioned in vertical alignment, and each spring 43 is arranged with its coil portion projecting inwardly and horizontally of the opposed end extensions 50 and 53 so as to leave clear the space between the member 44 and the housing 10 for upward movement of air entrained solids therethrough.

The member 44 is provided with circumferentially equally spaced openings 56 therethrough each of which receives a sleeve 57 and the lower end portion of a vertically adjustable bolt 45. Each of the bolts 45 is threaded and projects upwardly through an opening 60 formed in an arm 61 of the yoke 46, and is locked in an adjustable position relative to the arm by lock nuts 62 and 63.

In the construction described, the springs 43 are rigidly fixed with respect to the member 44 which in turn is vertically positioned with respect to the yoke 46 so that the grinding pressure exerted on the pulverizing zone 16 is adjustable. The springs are used to transmit rotational movement to the upper ring 27 from the drive mechanism. Simultaneously they restrain lateral movement of the ring 27 during rotation and by reason of the flexibility of the springs permit a restrained tilting of the ring 27, as may be caused by the presence of foreign materials, such as tramp iron, in the pulverizing zone 16. The positional relationship of the member 44, bolts 45 and the yoke arms 61 is such as to minimize abrasion of the bolts 45 by the rising stream of pulverized material entrained in the air, which occurs particularly adjacent the housing 10, and minimizes the imposition of bending forces on the adjustable bolts 45. In effect the bolts can be considered fixed end beams due to their fixed relationship to the annular member 44 and the arms 61 of the yoke.

As shown in FIG. 1, the shafts 33 and 47 are coaxial, with the shaft 47 supported by thrust bearing 62 and radial bearing 63 engaging the gear housing 15. Immediately above the bearing 62 the shaft 47 is provided with a gear ring 64 which is bolted to a hub 65. The gear ring 64 engages a worm 66 driven by a motor M2 to transmit rotational movement to the shaft 47.

The shaft 33, driving the lower ring 24, is coaxial with and supported on the shaft 47 through combination thrust and radial bearing 70 and radial bearings 71 and 72. The radial bearing 71 maintains the axial relationship of the shaft 33 with respect to the gear housing 15 while the radial bearing 72 maintains the coaxial relationship between shafts 47 and 33. The drive arrangement 34 includes a worm 73 driven by a motor M1 and drivingly engaging a worm-gear 74 affixed to the shaft 33.

The worm-gear drives and the bearings are suitably lubricated, and since the upper portions of both of the shafts extend into the housing 10 and are exposed to the material-laden air therein it is necessary to protect the bearing lubrication and bearing surfaces by a suitable air seal arrangement. Sealing air enters through a pipe 75 extending through the housing section 11 with a connecting duct 76 ending in an annular plenum chamber 79 adjacent the external surface of the rotating member 31. The member 31 is drilled to form air flow passageways 78 parallel to the axis thereof with the upper end opening into a rotating chamber 77 affixed to the upper end of shaft 33, while the lower end of the passageways are each provided with an outwardly opening radial extension 80 which is located at the level of the chamber 79. With the construction described, sealing air is introduced into the pipe 75 at a pressure in excess of the pressure prevailing within the pulverizer and passes from chamber 79 upwardly through the passageway 78 into the chamber 77. Any sealing air which escapes from the plenum chamber 79 between the rotating and stationary parts thereof discharges either downwardly and into the atmosphere or upwardly into the pulverizer housing beneath the member 31. The latter portion of escaping seal air eventually passes between the outer end of the arm 41 and the inner end of the part 42, and thus mingles with the carrier air passing through the chamber 40.

Since the chamber 77 rotates with the shaft 33 a running clearance is formed between the upper and lower walls 81 and 82, respectively, of the chamber so that some of the sealing air will escape in the space between the shaft 47 and the upper wall 81 into the interior of the pulverizer housing 10. The outward flow of such sealing air will prevent infiltration of dust-laden air into the bearings of the pulverizer drive shafts. The remainder of the sealing air delivered to the chamber 77 will discharge downwardly along the shaft 47, between the shaft and the end of the wall 82, into a chamber 83 and thence through one or more passageways 84 in member 31 into a space 85 beneath a stationary diaphragm plate 86 which forms the lower wall of the pulverizer housing section 14. The space 85 defined by the diaphragm 86 and the top of the gear housing 15 is open to the atmosphere.

The mixture of pulverized material and air passing upwardly in an annular stream adjacent the inner wall of the housing sections 13 and 14 enters the classifier 21 through a series of circumferentially disposed angularly positioned upright vanes 90 located downwardly adjacent the upper plate 91 forming the top of the pulverizer housing. The vanes 90 are attached to the plate 91 and are provided with adjustable end portions 90A which may be extended or retracted to alter the fineness characteristics of the finished product. The lower edges of the vanes 90 are attached to the base flange of an inverted frusto-conical member 92 extending downwardly to the annular opening 23 for the discharge of separated coarser solid materials from the classifier 21. The opening 22 in the top of the pulverizer is provided with a depending duct 94 extending downwardly into the classifier and thereby providing an outlet for air-borne classified material to leave the pulverizer housing 10. The lower end of the duct 94 is provided with an adjustable cylindrical member 95 which embraces the duct 94 and is vertically adjustable for a relatively minor regulation of the fineness limits of the materials discharged from the pulverizer.

As shown, the inner side of lower annular classifier discharge opening 23 is defined by a cylindrical cap member 96 which is attached to the yoke 46 and rotates therewith. The cap member protects the upper end of the shaft 47, and the yoke 46 attachment to the shaft, and provides a support for a vaned rotor 97 operating in the opening 23 to reduce the "back flow" or leakage of air-borne materials upwardly through the opening. A similar seal construction is disclosed in U.S. Patent 2,762,573.

In the operation of a pulverizer of the type described, the raw coal or other solid material to be pulverized enters the pulverizer housing 10 through the spout 18, is pulverized in the grinding zone 16 and discharged outwardly into an ascending circular stream of carrier air. The air enters the pulverizer through the annular passageway 38 from the duct 20 and passes upwardly through the annular throat 37 to lift the pulverized coal discharged by the grinding elements. The air passing through the throat is spinning in the same direction as the rotation of the lower ring 24, where such spin is imparted to the entering air by the vanes in the passageway 38. With the upper ring 27 rotating in a direction opposite to that of ring 24 the swirl of the air-borne pulverized coal passing upwardly along the wall of the housing 14 is largely dissipated with such air-borne pulverized coal movement being substantially vertical, particularly in the upper portion of the housing 13. It will also be noted the low centrifugal force of the balls 26 by reason of the counter rotation of the rings 24 and 27 assists in reducing the outward force of the pulverized coal passing through the grinding zone 16, and thus the control of coal flow through the grinding zone can be more easily regulated for high pulverizing efficiency.

In the embodiment of the invention, the pulverizer is rated for a grinding capacity of 50 tons per hour of a medium low grindability bituminous coal at a product fineness of 70% passing the 200 mesh U.S. Standard screen. To attain this capacity the pitch diameter of the grinding zone is 84 inches, the shaft 33 is rotated at 62 r.p.m. and shaft 47 is rotated at 82 r.p.m.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. A pulverizer comprising a housing, a lower rotary grinding ring, drive means including a first motor for rotating said lower grinding ring at a selected rate, a circular row of rolling grinding elements supported on said lower grinding ring, a rotary upper grinding ring supported on said grinding elements, drive means including a second motor for rotating said upper grinding ring at a selected rate and in a direction opposite to the direction of rotation of said lower grinding ring, means for delivering material to be pulverized to said row of grinding elements, and means for directing a stream of carrier air past the material discharge side of said grinding elements for withdrawing pulverized material from said housing.

2. A pulverizer comprising a housing having an outlet in the upper portion thereof and enclosing a lower rotary grinding ring, drive means including a first motor for rotating said lower grinding ring, a circular row of rolling grinding elements supported on said lower grinding ring, a rotary upper grinding ring supported on said grinding elements, drive means including a second motor for rotating said upper grinding ring in a direction opposite to the direction of rotation of said lower grinding ring, the rates of rotation of said upper and lower grinding rings being regulated by said first and second motors selectively and different to produce a low value of centrifugal force on said rolling grinding elements, classifier means positioned in the upper portion of said housing above said upper grinding ring, means for delivering material to be pulverized to said row of grinding elements, and means for directing a stream of carrier air past said grinding elements to entrain pulverized material for delivery to said classifier means and the discharge of finished product through said outlet.

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